STUDY OF THE SPHERICITY OF PEBBLES FROM THE LOWER WISCONSIN TERRACES HOCKING RIVER VALLEY, OHIO

Senior Thesis
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ABSTRACT

This paper deals with the study of sphericity of pebbles found in some of the lower Wisconsin terraces of the Hocking River Valley, Ohio. The intent was to show increase in sphericity with distance of transport. However, this was not observed. A possible explanation is that the sphericity may only indicate energy level of the environment at the various terraces.

Statement of the Problem

The environmental condition under which a deposit was formed, such as distance of transport, has been of interest for many years. These conditions are often reflected in the physical properties of the sediments. Among these is the one considered in this paper, that of sphericity. It has been shown by Krumbein, 1941, that sphericity increases slightly with distance of transportation. He demonstrated this by tumbling pebbles in a cylinder. This paper attempts to find the same relationship occurring in natural stream gravels.

This study was made by collecting pebble samplings from the lower Wisconsin terraces which occur along the Hocking River Valley from Carroll, Ohio, southward. The locations for collection, which will be mentioned later, were located by the use of Kempton's Master's thesis, 1953-54, and the Glacial Map of Fairfield County, Ohio, 1962, Plate 2, Bulletin 60. Only the locations shown in both papers were used.

Review of Some Previous Experimentation

The property of sphericity, roundness, and other products of stream abrasion, has been under some study for many years. Krumbein, 1935, gives a good historical account of previous studies, therefore, here a short summary will be given with some reference to more recent papers. Wentworth, in a series of papers from 1919-1933, comes to the following conclusions about stream-abraded rocks by use of a tumbler:

1. The fundamental characteristics of sediments which change during abrasion are size, shape and surface texture.

2. Factors which control the changes in sedimentary character during abrasion include, among others, size, angularity (roundness), kind of rock, violence of abrasion process, and distance.
3. Roundness as a function of distance transported is represented by a graph which rises rapidly at first and then more gradually. In exceptional instances roundness may even decrease after reaching a maximum value.
4. Size as a function of distance is a negative exponential function.
5. Roundness may be a function of size as well as hardness.

Wedell, 1932, explains sphericity by his equation $s/S = \psi$ where s = surface area of a sphere of the same volume as the rock specimen, and S = the actual surface area of the specimen, ψ being the sphericity which would have a maximum value of one. His method requires measurement of the pebble's volume and longest diameter. From this data, the diameter of a sphere with the same volume can be determined. He explains his method of measurement of sand-sized particles in his paper of 1935.

Krumbein, 1941, has a somewhat more rapid method of calculating sphericity which he calls his "intercept method". His formal routine for determination is the one followed in this paper. It goes as follows:

1. The longest axis is measured first as shown in figure one.

2. The pebble is then held with the longest axis between the thumb and forefinger and rotated in order that the second longest diameter may be measured, perpendicular to the long axis.
3. The pebble is then again held as in step two and rotated so that the shortest diameter, which must be perpendicular to both the long and medium diameters, can be measured.
4. The long axis is then labeled "a", the medium axis "b" and the short axis "c".
5. In addition to these steps, explained somewhat the same by Krumbein for this experiment, lithologies were also checked and classified as to clastic, carbonate or crystalline.
6. From this data the ratios b/a and c/b can be calculated and then plotted on a graph as in Graph I, from which the sphericity can be read. (The dark curved lines on the graph are plotted by the use of the equation $(b/a)^2 = \frac{\psi^3}{c/b}$ which is derived in Krumbein's paper.)

Krumbein, 1941, made tests by way of a tumbler which was equivalent to a transportation distance of twenty miles. The arithmetic mean sphericity changed from .65 at the beginning to .77 at the end, a change of only .12, with an almost linear slope. Therefore, the stops in this paper may at first seem far apart. However, to demonstrate a slowly

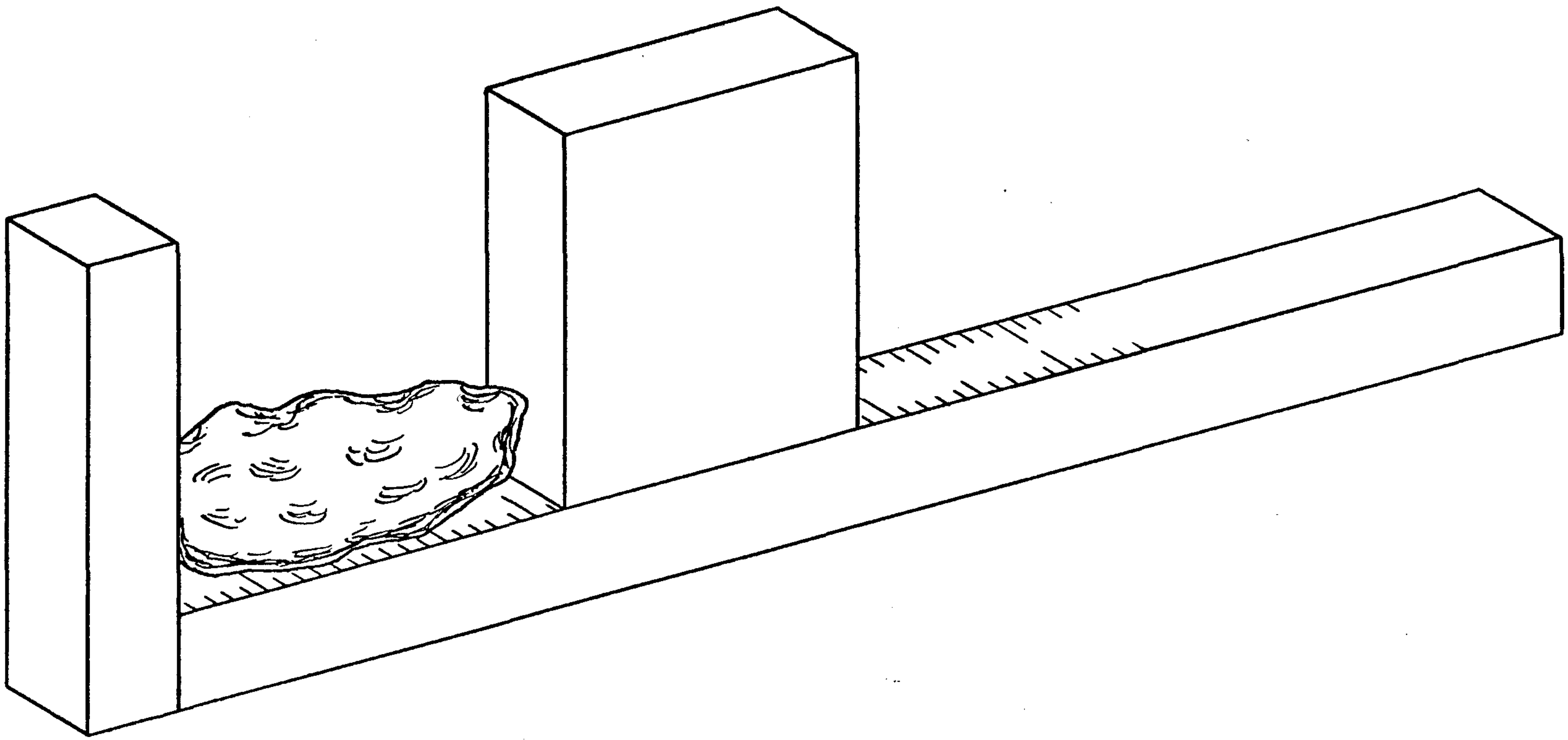


Fig 1

changing parameter such as this, it seemed advisable.

The obvious factor which is not taken into consideration when a tumbler is used is that the higher the sphericity, the more likely a pebble is to be deposited. In other words, at a specific energy level, only pebbles of a specific sphericity and below would tend to be transported.

The following pages contain the calculated data from each collecting station followed by a graphic representation for each station. At the end of this section a table of arithmetic mean sphericities as compared to distance from the first station and lithology will be given.

Location of Stations

Station No. 1 Northwest corner of Section 12, Range 19 West,
7.5'
Township 14 North, of the Carroll Quadrangle. Carroll kames.

Station No. 2 North central part of Section 7, Range 18 West,
7.5'
Township 14 North, Carroll Quadrangle, either in Carroll or south of town.

Station No. 3 Northeast corner of Section 33, Range 19 West,
7.5'
Township 15 North, Amanda Quadrangle, south of Hooker

Station No. 4 Northeast 1/4, of the Southeast 1/4, of Section 7,
Range 18 West, Township 14 North, of Lancaster 7.5' Quadrangle (s.e. of "Whites")
?28?

Station No. 5 Northeast 1/4 of Section 25, Range 18 West,
Township 14 North, of Lancaster 7.5' Quadrangle

Station No. 6 Northeast 1/4, of the Southwest 1/4, of Section 33,
Range 18 West, Township 14 North, at the end of the dead-end road heading South.

STATION I

No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.70	.49	.62	Cl	26	.62	.73	.65	C
2	.81	.51	.70	C	27	.83	.68	.78	Cl
3	.55	.58	.55	C	28	.68	.73	.70	C
4	.81	.84	.81	C	29	.67	.64	.66	C
5	.57	.16	.37	Cl	30	.93	.96	.95	C
6	.97	.77	.90	C	31	.79	.40	.63	C
7	.72	.70	.71	C	32	.78	.75	.78	C
8	.86	.64	.78	Cl	33	.81	.48	.69	Cl
9	.80	.55	.70	C	34	.95	.35	.69	C
10	.95	.70	.86	Cl	35	.88	.75	.83	Cr
11	.64	1.00	.74	Cr	36	.78	.36	.60	Cl
12	.82	.42	.65	Cr	37	.89	.33	.64	Cl
13	.75	1.00	.82	C	38	.67	.56	.73	C
14	.87	.73	.81	Cr	39	.79	.80	.79	Cr
15	.55	.50	.53	C	40	.53	.60	.55	Cl
16	.63	.65	.74	C	41	.80	.88	.82	C
17	.71	.88	.76	C	42	.86	.67	.79	C
18	.87	.59	.76	C	43	.82	.86	.82	C
19	.78	.43	.66	Cl	44	.69	.64	.78	C
20	.75	.84	.78	C	45	.80	.40	.64	Cr
21	.61	.73	.65	C	46	.80	.75	.79	C
22	.86	.96	.90	C	47	.11	.93	.20	Cl
23	.75	.67	.72	C	48	.11	.40	?	C
24	.67	.58	.64	Cr	49	.56	.83	.64	C
25	.70	.50	.62	Cl	50	.88	.72	.81	C

Cl. - Clastics C. - Carbonates Cr. - Crystallines

STATION II

No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.63	.88	.79	Cl	26	.95	.61	.81	C
2	.56	1.00	.69	C	27	.62	1.00	.72	C
3	.96	.82	.91	C	28	.65	.91	.73	C
4	.83	1.00	.89	C	29	.71	.75	.72	Cr
5	.89	.88	.89	C	30	.70	.63	.68	Cl
6	.68	.87	.74	Cr	31	.63	.83	.70	Cl
7	1.00	.67	.87	Cl	32	.81	.62	.69	C
8	.94	.47	.60	Cl	33	.81	.92	.85	Cl
9	.75	.60	.70	C	34	.80	.92	.83	C
10	.65	.95	.83	C	35	.87	.61	.78	C
11	.83	.83	.83	C	36	.63	.71	.65	C
12	.73	.54	.60	C	37	.77	.54	.69	Cl
13	.77	.35	.60	C	38	.77	.54	.60	C
14	.79	.63	.73	C	39	.63	.80	.69	C
15	.94	.68	.75	C	40	.81	.54	.71	Cl
16	.71	.83	.79	Cl	41	.74	.71	.72	Cl
17	.77	.70	.74	C	42	.95	.78	.89	C
18	.88	.60	.78	C	43	.80	.59	.72	C
19	.68	.93	.75	C	44	.75	.67	.72	Cl
20	.82	.60	.66	C	45	.86	.67	.79	Cr
21	.68	.70	.69	C	46	.77	.60	.71	C
22	.79	.73	.77	C	47	1.00	.81	.93	C
23	.94	.93	.94	C	48	.75	.42	.61	Cl
24	.89	.78	.85	Cl	49	.80	.42	.65	C
25	.78	.65	.73	Cl	50	.74	.85	.78	Cl

STATION III

No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.78	.65	.74	Cr	26	.68	.52	.62	C
2	.82	.83	.82	Cl	27	.74	1.00	.81	C
3	.60	.76	.65	Cl	28	.67	.61	.65	C
4	.81	.90	.84	Cl	29	.70	.72	.71	C
5	.56	.60	.58	C	30	.74	.82	.76	C
6	.50	.42	.48	Cl	31	.59	.68	.61	Cl
7	.83	.83	.83	C	32	.59	.80	.69	C
8	.85	.65	.78	C	33	.63	.41	.55	Cl
9	.81	.77	.80	Cl	34	.70	.93	.77	Cl
10	.79	.60	.72	C	35	.78	.61	.71	Cl
11	.79	.60	.72	Cl	36	.73	.77	.74	C
12	.76	.82	.78	C	37	.68	.41	.58	C
13	.80	.80	.80	Cl	38	.82	.74	.79	C
14	.70	.78	.72	Cr	39	.78	.86	.80	Cl
15	.75	.67	.72	C	40	.73	.75	.74	Cl
16	.72	.52	.65	C	41	.58	.91	.69	Cl
17	.89	.81	.86	C	42	.73	.73	.73	C
18	.76	.89	.80	Cl	43	.86	.83	.85	C
19	.86	.84	.85	C	44	.75	.53	.67	C
20	.61	.68	.63	Cl	45	.90	.50	.73	C
21	.83	.67	.78	Cr	46	.94	.67	.84	Cr
22	.85	.58	.75	Cl	47	.68	1.00	.78	C
23	.90	.79	.85	Cl	48	.42	.90	.54	C
24	.89	.44	.70	C	49	.88	.93	.90	C
25	.67	.46	.60	Cl	50	.96	.48	.76	Cl

IX

STATION IV

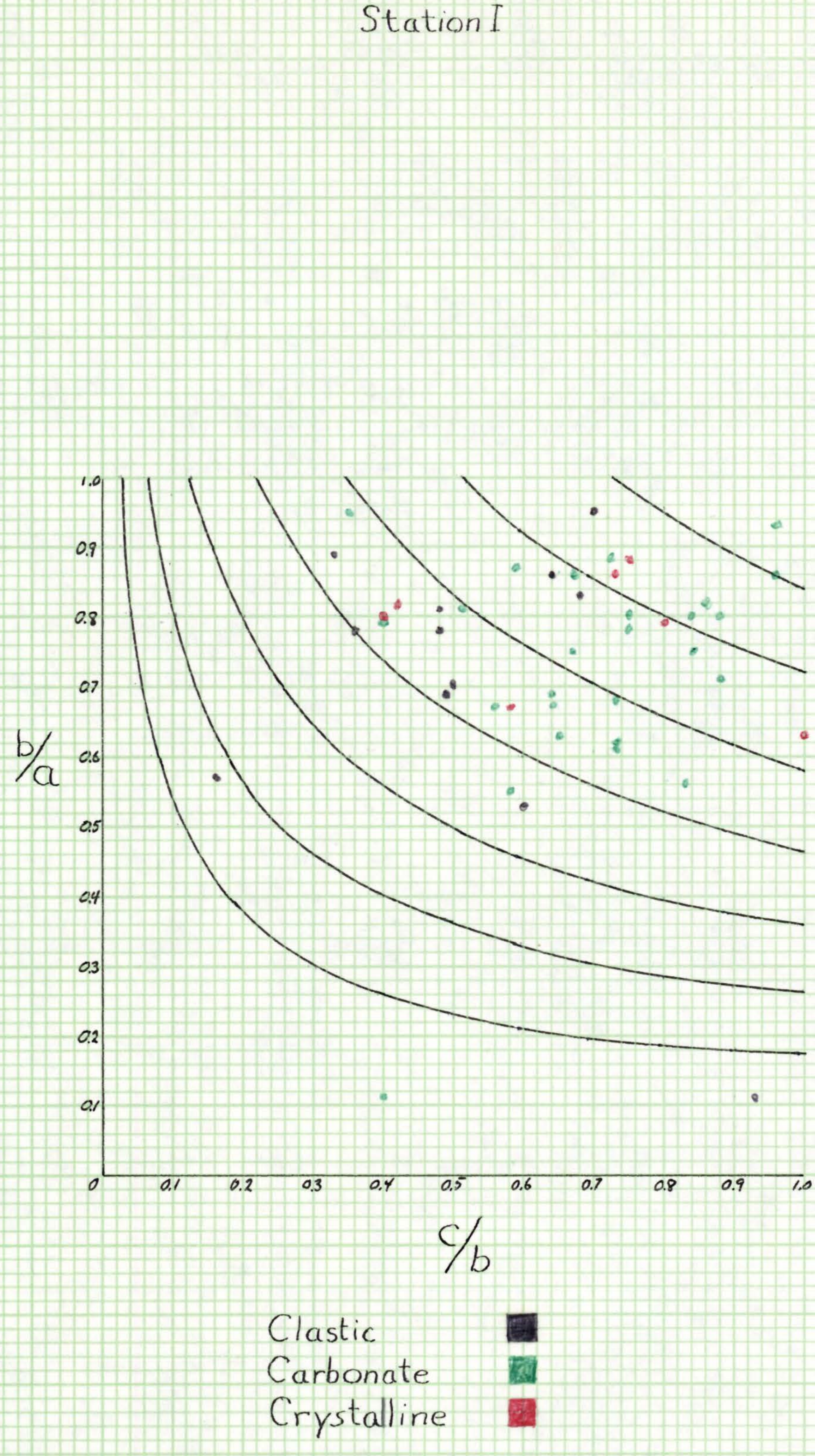
No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.84	.52	.71	Cl	26	.81	1.00	.88	Cl
2	.63	.90	.71	C	27	1.00	.56	.82	Cl
3	.51	.32	.44	Cl	28	.57	.46	.53	Cl
4	.65	.77	.69	Cl	29	.47	.29	.40	Cl
5	.72	.56	.66	C	30	.44	.59	.49	Cl
6	.78	.67	.74	Cl	31	.73	.55	.67	C
7	.70	.58	.66	Cl	32	.63	.50	.59	Cl
8	.46	.26	.38	Cl	33	.65	.54	.61	Cl
9	.84	.63	.76	Cr	34	.70	.63	.68	Cl
10	.86	.72	.81	Cr	35	.75	.53	.67	Cl
11	.91	.60	.80	Cr	36	.55	.67	.59	Cl
12	.68	.79	.71	Cl	37	.81	.92	.85	Cl
13	.82	.50	.70	Cl	38	.80	.31	.59	Cl
14	.86	.67	.79	Cl	39	.86	.58	.75	Cr
15	.77	.69	.74	C	40	1.00	.75	.91	Cr
16	.81	.29	.58	Cl	41	.86	.58	.75	C
17	.77	.48	.66	Cl	42	.92	.45	.72	Cr
18	.88	.18	.52	Cl	43	.77	.80	.79	Cl
19	.72	.77	.74	Cl	44	.90	.22	.56	Cl
20	.68	.80	.72	C	45	.90	.53	.75	Cl
21	.80	.75	.78	Cl	46	.89	.63	.80	C
22	.72	.77	.74	C	47	.94	.33	.67	Cl
23	.80	.75	.79	Cl	48	.79	.45	.65	Cl
24	.78	.75	.79	C	49	.92	.64	.81	Cr
25	.74	.31	.55	Cl	50	.62	.89	.70	Cl

STATION V

No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.82	.72	.79	Cr	26	.85	.59	.75	Cr
2	.75	.72	.74	Cr	27	.95	.24	.60	Cl
3	.56	.80	.62	Cl	28	.50	.50	.50	Cl
4	.75	.75	.75	C	29	.68	.46	.60	Cl
5	.79	.67	.75	C	30	.62	.85	.69	Cl
6	.71	.94	.79	Cr	31	.83	.60	.75	Cl
7	.68	.67	.68	Cl	32	.86	.50	.71	Cl
8	.62	.72	.65	Cl	33	.85	.64	.78	Cr
9	.79	.82	.80	Cl	34	.71	.41	.59	Cl
10	.75	.67	.72	Cl	35	.85	.45	.69	Cl
11	.93	.69	.85	Cl	36	.65	.91	.73	Cl
12	.71	.53	.65	Cl	37	.60	.68	.62	Cl
13	.40	.29	.36	Cl	38	.87	.23	.55	Cl
14	.70	.93	.78	Cl	39	.69	.67	.69	Cr
15	.40	.88	.51	Cl	40	.86	.75	.82	C
16	.58	.57	.58	Cl	41	.73	.55	.67	C
17	.74	.29	.55	Cl	42	.83	.20	.51	Cl
18	.86	.58	.75	Cl	43	1.00	.42	.75	Cl
19	.75	.56	.69	Cl	44	.91	.80	.87	Cr
20	.80	.50	.69	C	45	.69	.67	.69	Cl
21	.75	.89	.79	Cl	46	.89	.75	.84	Cl
22	.93	.77	.88	Cr	47	.83	.60	.75	Cl
23	.83	.87	.85	C	48	.82	.78	.80	Cl
24	.93	.57	.80	Cl	49	.67	.40	.57	Cl
25	.77	.80	.79	Cl	50	.59	.70	.69	Cl

STATION VI

No.	b/a	c/b		lith.	No.	b/a	c/b		lith.
1	.96	.43	.73	Cl	26	.57	.50	.55	Cl
2	.78	.67	.73	Cl	27	.95	.65	.84	Cl
3	.69	.63	.67	Cl	28	.70	.57	.65	Cl
4	.71	.83	.75	Cl	29	.87	.69	.80	Cr
5	.48	.73	.55	Cl	30	.83	.80	.82	Cr
6	.64	.67	.65	Chert	31	.73	1.00	.90	Cl
7	.60	.93	.70	Cr	32	.95	.68	.85	Cl
8	.81	.47	.68	Cl	33	.91	.37	.67	Cl
9	.85	.65	.78	Cl	34	.78	.83	.80	Cl
10	.81	.73	.78	Cr	35	.50	.92	.61	Cl
11	.80	.83	.81	Cl	36	1.00	.58	.83	Cl
12	.86	.75	.82	Cl	37	.64	.71	.66	Cl
13	.84	.43	.68	Cl	38	.79	.73	.78	Cl
14	.87	.60	.77	Chert	39	.57	1.00	.69	C
15	.84	.86	.85	Cr	40	.62	.63	.62	Cl
16	.90	.72	.83	Cl	41	.86	.42	.68	Chert
17	.65	.82	.70	C	42	.63	.40	.55	Cl
18	.87	.38	.67	Cl	43	.73	.75	.74	Cl
19	.70	.63	.69	Cl	44	.48	.90	.60	C
20	.67	.71	.69	Cl	45	.93	.79	.88	Cl
21	.81	.62	.74	Cr	46	.79	.45	.65	Cl
22	.80	.38	.62	Cr	47	.88	.57	.77	Cl
23	.82	.43	.69	Chert	48	1.00	.62	.85	Cr
24	.93	.10	.44	Cl	49	.72	.60	.69	Cl
25	.72	.85	.75	Cr	50	.72	.92	.79	Chert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0
0.1
0.2
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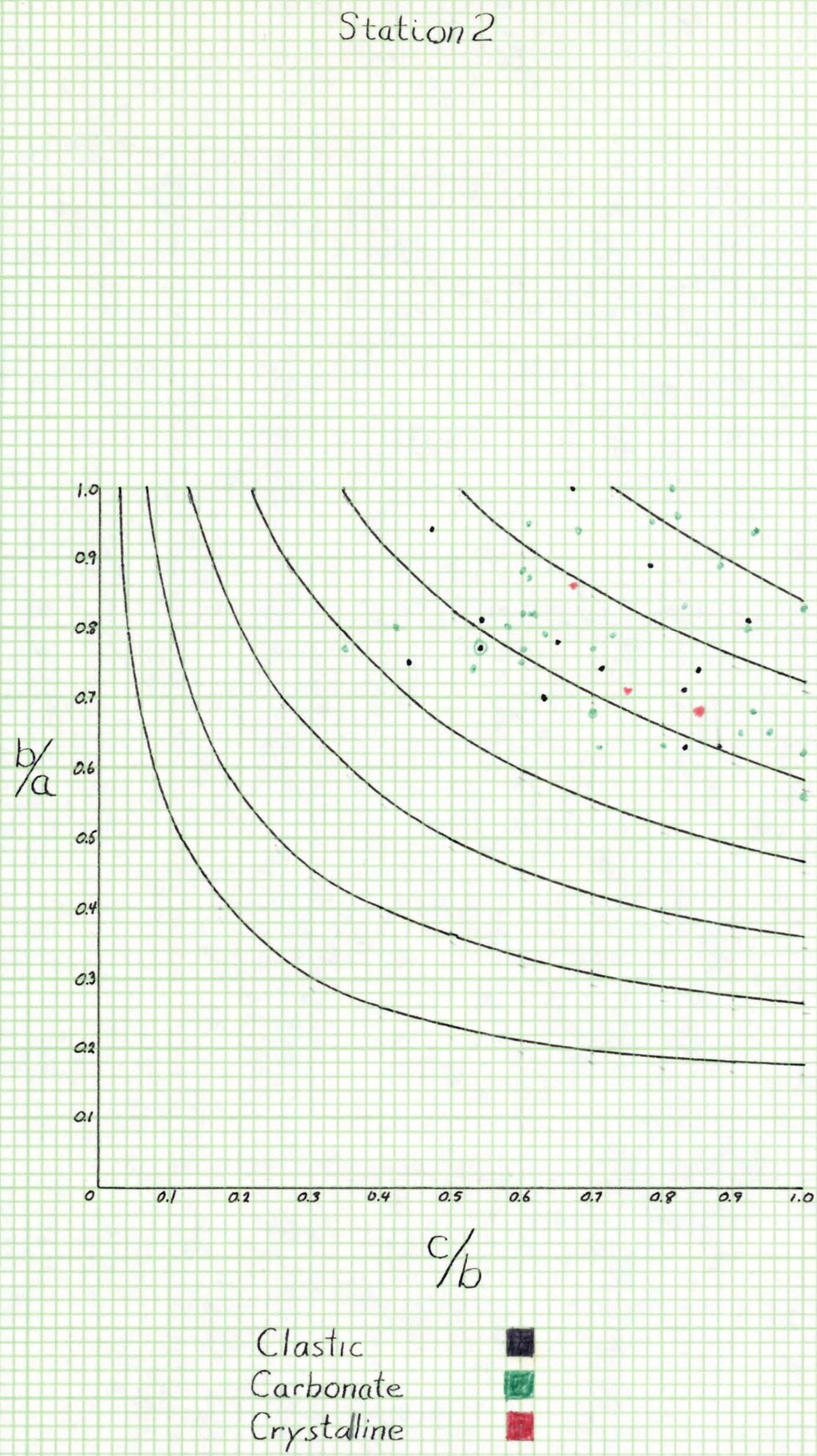
1.0
c/b
Clastic
Carbonate
Crystalline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0
0.1
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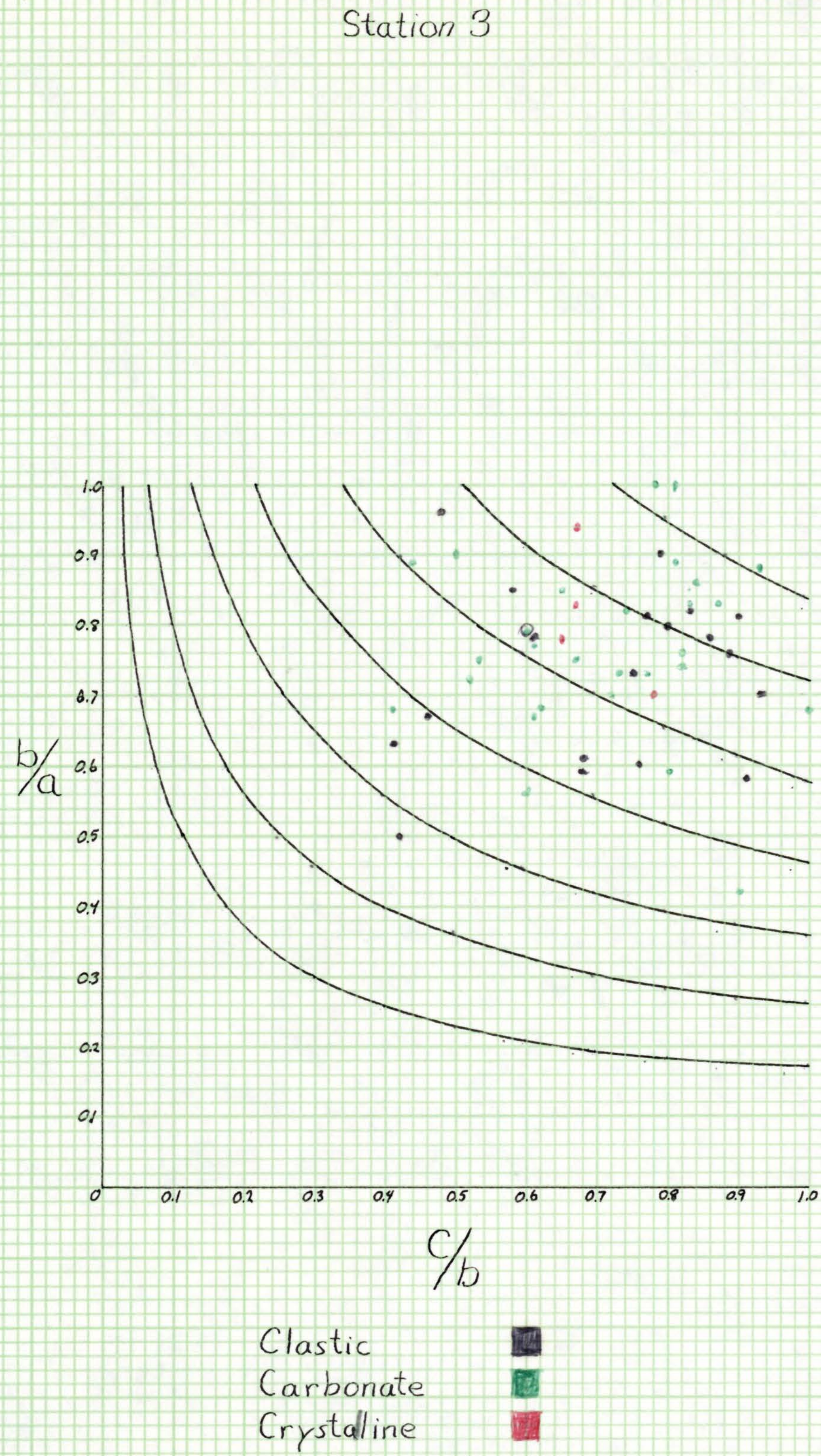
0.5
0.6
0.7
0.8
0.9
1.0
Clastic
Carbonate
Crystalline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0.5
0.4
0.3
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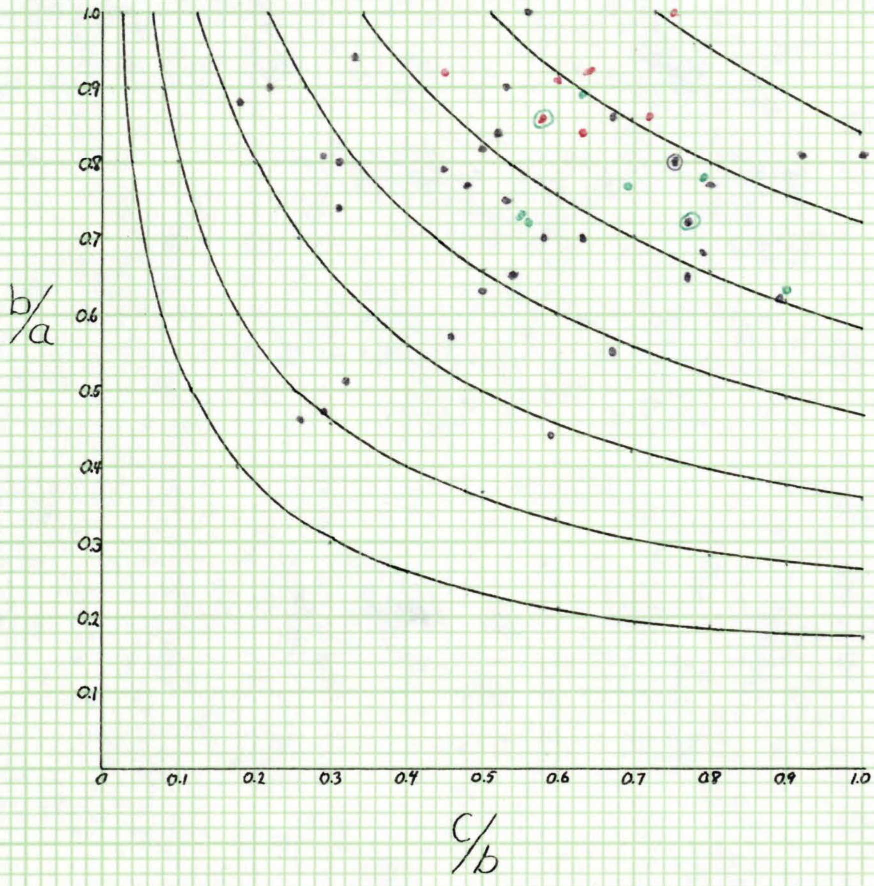
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
c/b
Clastic
Carbonate
Crystalline

Station 4

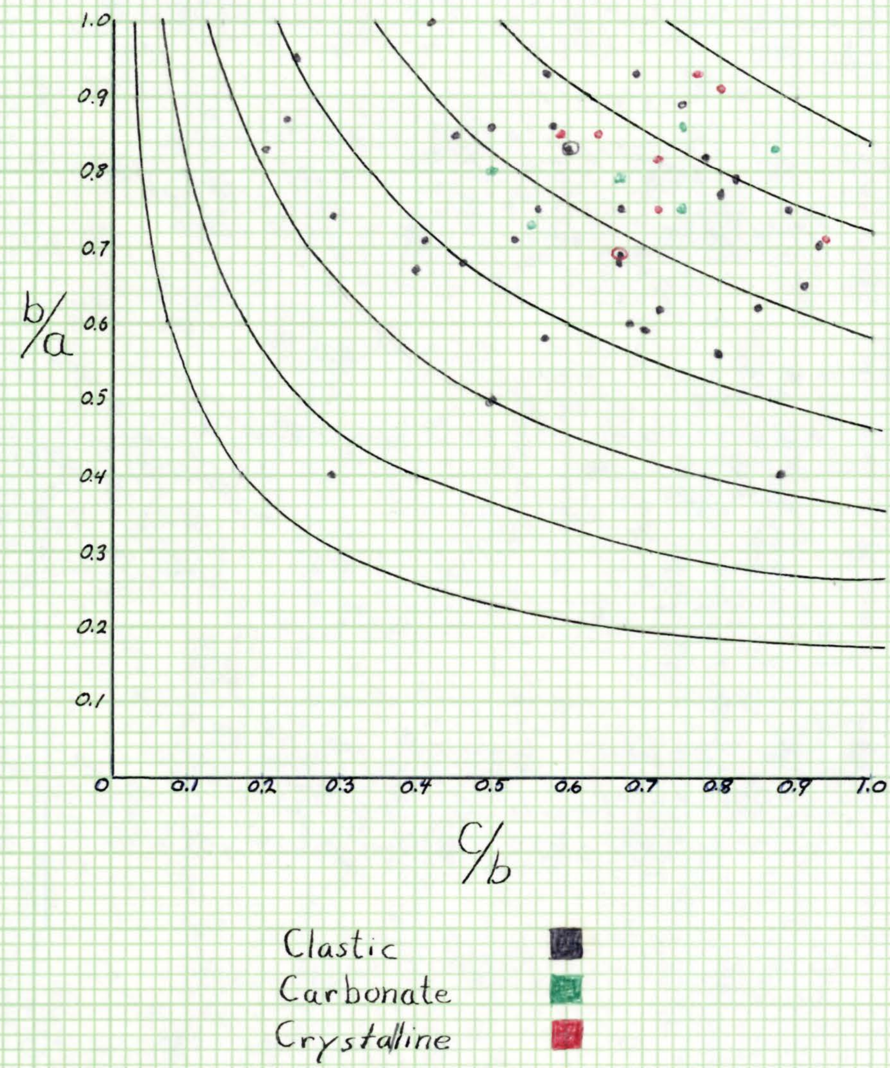


Clastic

Carbonate

Crystalline

Station 5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0.4
0.3
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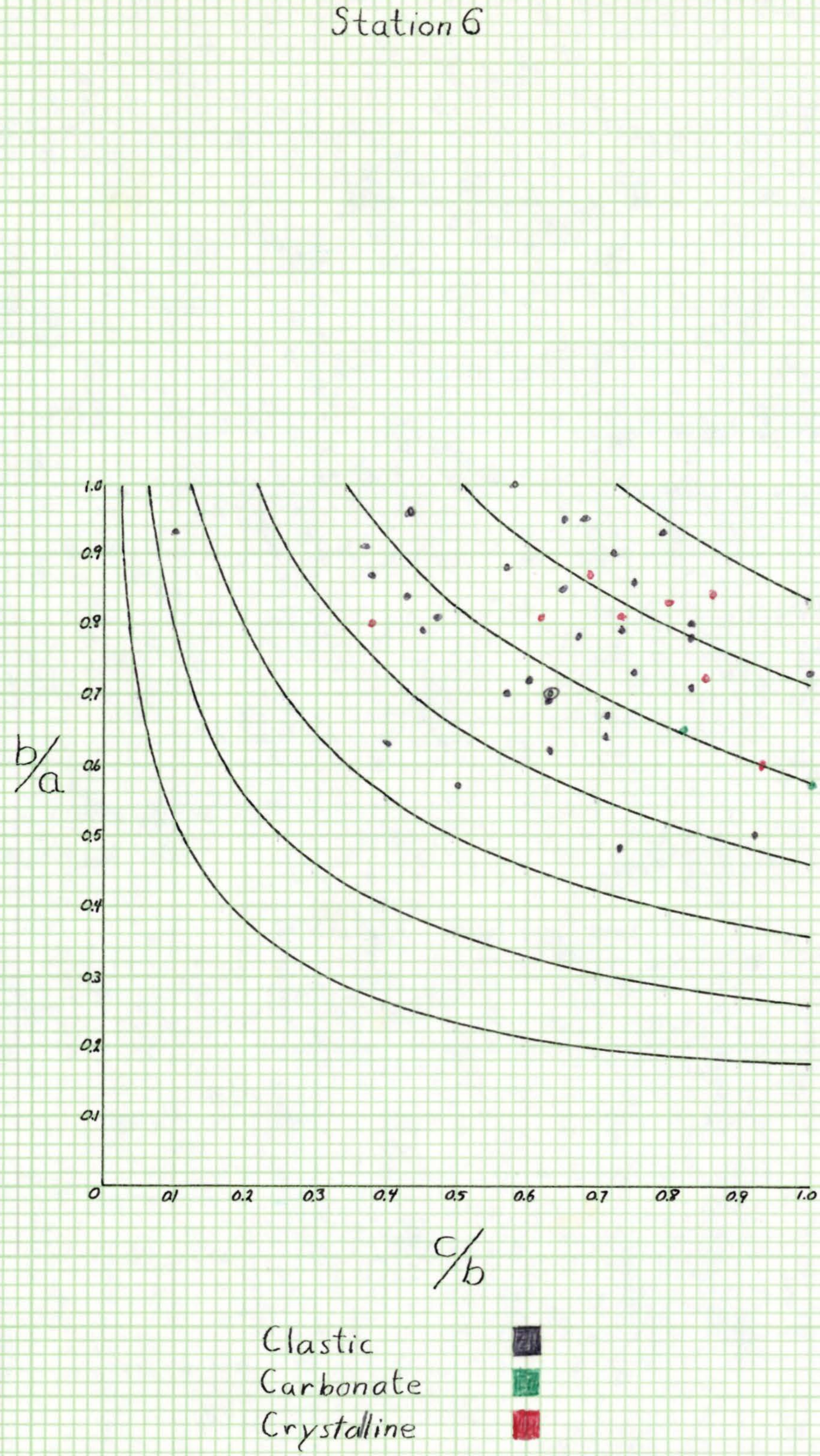
b/a
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
c/b
Clastic
Carbonate
Crystalline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0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
c/b
Clastic
Carbonate
Crystalline

S U M M A T I O N

Station No.	Feet	Avg. ψ for Carbonates "decreased" downstream	Avg. ψ for Clastics "increased" downstream	Avg. ψ for Crystallines increased downstream
1	0	.733	.614	.637
2	5,000	.755	.740	.751
3	29,000	.732	.719	.770
4	54,000	.732	.655	.794
5	71,000	.755	.673	.787
6	78,500	.647	.714	.757

Conclusions

The summation shows that in the clastics the increase in sphericity has been over-shadowed by other factors such as the great increase in clastics from the surrounding bedrock. The crystallines, presumably, should have given the best results because of their one primary source, the glaciers. They show a steady increase until the fifth station was reached, at which point, they decrease. The carbonates disappear almost completely, due probably to abrasion, etc.

From the above evidence, the expected increase in sphericity was not observed, quite likely due to the fact that deposition due to sphericity depends directly on the energy of the environment. If one terrace were at one time exposed to more energy than another through stream gradient, etc., the sphericities of the pebbles found in the two should vary from the terrace gravels deposited at a higher or lower energy level.

An interesting experiment for a future time would be to show by some apparatus and actual stream study, that the stream energy at any one point and time is reflected in its bank gravels.

REFERENCES CITED

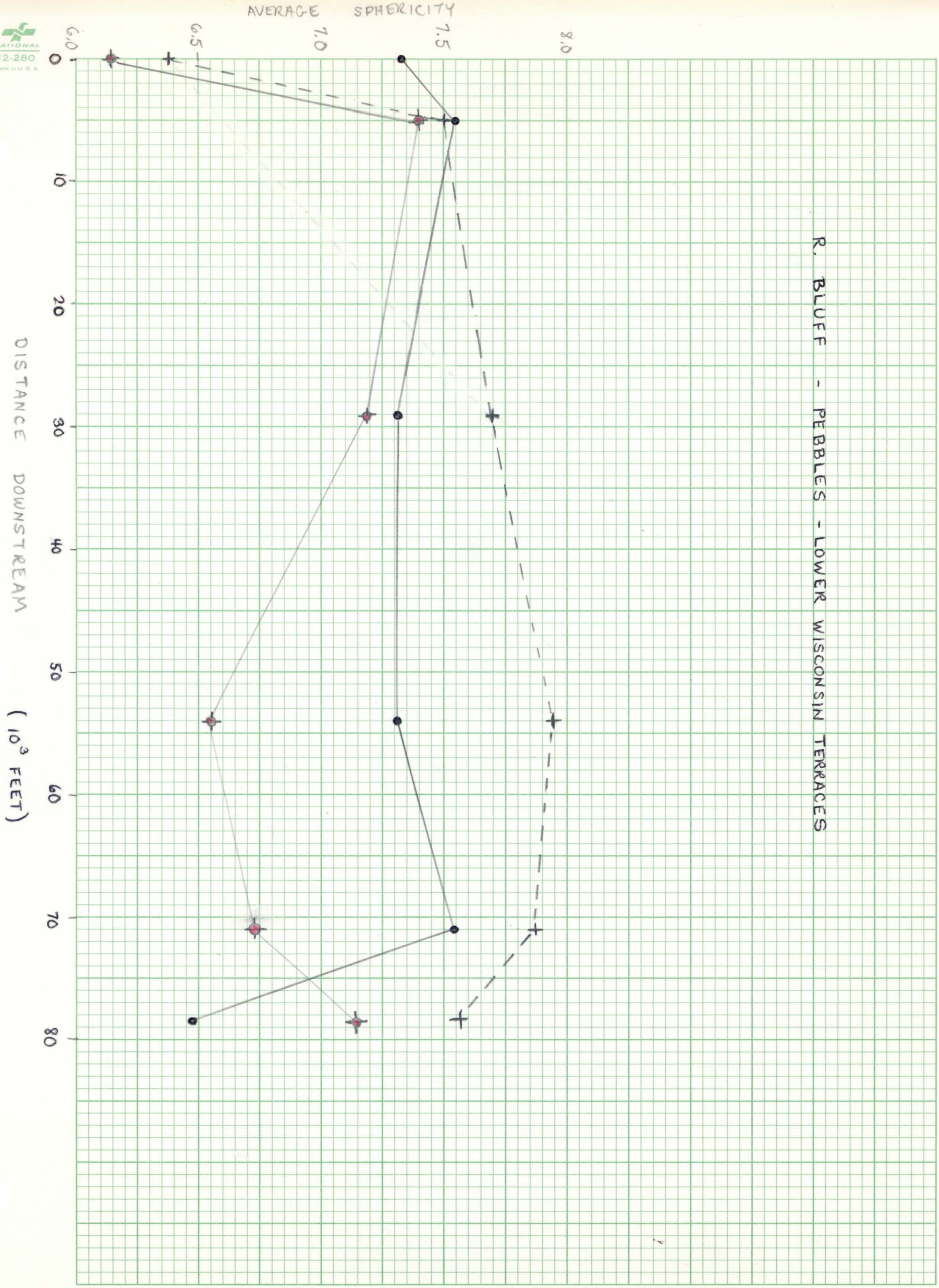
Kempton, John Paul, 1953-54, Outwash terraces of the Hocking River Valley, Ohio, Master's Thesis, Ohio State University.

Krumbein, W. C., 1935, The effect of abrasion on the size, shape and roundness of rock fragments, Journal of Geology, Vol. 49,p. 482-520.

Krumbein, W. C., 1941 , Measurement and geological significance of shape and roundness of sedimentary particles, Journal of Sedimentary Petrology, Vol. 11, p. 64-72.

Wadell, Hakon, Volume, shape and roundness of rock particles, Journal of Geology, Vol. 40, p. 443-451.

Wadell, Hakon, Volume, shape and roundness of quartz particles, Journal of Geology, Vol. 43, p. 250-280.


AVERAGE SPHERICITY
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6.5
7.0
7.5
8.0
0
10
20
30
40
50
60
70
80
DISTANCE DOWNSTREAM
(10^3 FEET)
R. BLUFF - PEBBLES - LOWER WISCONSIN TERRACES

E. McSAVENEY